TRANSACTIONS
OF THE
ROYAL SOCIETY OF NEW ZEALAND

ZOOLOGY

VOL. 7 NO. 3 AUGUST 6, 1965

Muraenid Leptocephali in Australasian Waters

By P. H. J. CASTLE,

Department of Zoology, Victoria University of Wellington, N.Z.

[*Received by the Editor, 8 February 1965.*]

Abstract

EEL-LARVAE of the Muraenidae are usually of moderate size (60mm–70mm when full-grown), they have a rounded caudal fin, the vent placed more usually in the second third of the body, pectoral much reduced or absent, myomeres between 100 and 220 and in most species inconspicuous but characteristic pigmentation. In a collection of over 100 specimens assembled from New Caledonian waters and from the east and west coasts of Australia there are 26 species, referable to a possible seven genera and including *Gymnothorax, Uropterygius, Anarchias, ?Rabula* and *?Echidna.* As with other eel families generic divisions are suggested in these muraenid leptocephali by readily observable differences in pigmentation. Sizes of larvae indicate that muraenid eels probably spawn relatively close to the area of normal adult distribution and that larval life is relatively short, possibly about eight to ten months.

INTRODUCTION

THE large collection of over 1,100 eel-larvae from the Australasian region upon which this and preceding reports (Castle, 1963a–1965) are based contains a considerable number of leptocephali belonging to the Family Muraenidae and it is therefore a typical one for tropical waters. These numerous muraenid leptocephali reflect the abundance of adults of this family in these waters. The muraenid eel-larvae in this collection number 113 specimens, referable to 26 species and possibly seven genera. Three of these genera have been positively identified and the identity of two others is tentatively suggested. However, until sufficient transitional metamorphic larvae are collected and a more critical examination made of adult muraenid eels in the Indo-Pacific, the species to which the above 26 forms belong must necessarily remain unknown. These are indeed the two major difficulties encountered in the identification of the leptocephali of most families of eels (and in particular the Muraenidae and Ophichthidae).

In the present collection there are a number of transitional metamorphic larvae which could be expected to show definitive characteristics of their adult genera and thus provide a basis for final generic identifications. Unfortunately, only a few of these belong to the muraenid genera (*Uropterygius*, Rüppell, 1835 and *Anarchias* Jordan and Starks, 1906) in which readily observable superficial characters develop early in the metamorphosis of the larva, enabling recognition of

Published by the Royal Society of New Zealand, c/o Victoria University of Wellington, P.O. Box 196, Wellington.

these genera at the leptocephaline stage. The characters referred to are the presence of reduced dorsal and anal fins with very few fin-rays and the presence (*Anarchias*) or absence (*Uropterygius*) of a conspicuous cephalic sensory pore immediately behind the posterior nostril. The muraenid genera of the *Gymnothorax* Bloch, 1795—*Siderea* Kaup, 1856—*Echidna* Forster, 1777 group, and others, have long dorsal and anal fins, the dorsal originating over the branchial region. There are numerous leptocephali in the present collection which show relatively well developed dorsal and anal fins and are therefore referred to this group of genera. Further identification even to genus within this group may be difficult since the major basis for separation of these genera in the young elver and adult is the shape and arrangement of the definitive teeth. These teeth unfortunately do not appear until the metamorphosis of the larvae is almost complete. *Rabula* Jordan & Davis, 1888 is regarded as intermediate between the *Uropterygius* and the *Gymnothorax* groups in having a dorsal origin between the levels of the branchial aperture and vent. The difficulty in recognising larvae of this genus as compared with those of the *Gymnothorax* group lies in the fact that the origin of the dorsal, as is characteristic of those eels with an anteriorly-placed dorsal origin, does not reach its final forward position until the larva has almost completed metamorphosis. Nevertheless, at least one late metamorphic specimen shows a clearly stabilized dorsal origin in advance of the level of the vent and can therefore be referred with confidence to *Rabula*.

Progressive examination of a series of specimens from the few metamorphic individuals which do indeed possess definitive generic features through to much younger larvae has here determined the characteristic morphology of typical leptocephali of these genera. There are in the present collection seven clearly distinguishable groups of larvae which are here regarded to represent seven genera. Two of these groups can each be subdivided further into what may later prove to be subgenera. The major distinguishing feature of these "genera" is the amount and distribution of chromatophores, and in this way the muraenid leptocephali follow closely the larvae of the Congridae and other eel families.

No broad, critical study of muraenid species from the Indo-Pacific has yet been made. A conservative estimate through the literature indicates that there are about 60–70 species in this region, possibly referable to as many as a dozen genera. Of this number of species I can find only eight which have their vertebral counts known, and the family is therefore largely unknown in this respect. The specific identification of the 26 species described below is therefore impossible at the present time since, as with other families of eels, knowledge of the number of vertebrae is necessary for the characterisation of muraenid species. Unlike many other families, however, the number of species in some muraenid genera (and in particular *Gymnothorax* with its 30–40 species) is so great that there must obviously be confusion if vertebral counts alone are taken as the major distinguishing specific character (especially since the range of vertebral numbers in the whole family is probably from about 100 to 220).

Adult and young muraenids are relatively so abundant in shallow, tropical waters that it is not surprising to find their leptocephali present in moderate numbers in collections of eel-larvae from these waters. Their frequency in these collections is perhaps the reason why as many as 25 different types of muraenid leptocephali have been described from the Indo-Pacific. Only four of these have been tentatively or positively identified. These are *L. Gymnothorax undulatus* (Lacépède, 1803) and *L. Gymnothorax hepaticus* Rüppell, 1828, known from the Red Sea (Ancona, 1928, p. 75, pl. 4, figs. 9–11b; p. 82, pl. 4, figs. 14–16b, respectively); *L. Gymnothorax tile* (Hamilton-Buchanan, 1822) from Bengal (Jones & Pantalu, 1952); and *L. Thyrsoidea macrura* (Bleeker, 1854) from

Madras (Nair, 1947, p. 8, figs. 7–11, pl. 2, figs. 1–2). The remainder clearly belong in the Muraenidae but further identification of these types to either genus or species has not yet been achieved.

I am indebted to the following institutions which have kindly placed specimens on loan: the Centre d'Océanographie de l'Institut Français d'Océanie, Nouméa, New Caledonia; the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, N.S.W., Australia; the Australian Museum, Sydney; the Western Australian Museum, Perth.

Systematic Account

On the basis of the few reliable identifications that have already been made and the material studied in the preparation of this paper, muraenid leptocephali may now be characterised as follows:

Leptocephali of moderate size (few recorded examples being longer than 100mm with most full-grown specimens at about 60mm); with a relatively shallow body, a short, blunt snout (except in young examples of less than 25mm) and a rounded caudal fin supported by few rays and two indistinct hypurals; the vent is never subterminal and even in early development is usually placed in the middle of the body or a little behind this; the teeth are in moderate number (usually about 10 on each side of the jaws, in three groups); the pectoral fin is seldom more than a minute, fleshy flap (even in very small specimens), but is more usually absent; myomeres for the family from about 100 to about 220 with the range in any particular species usually about 10; pigmentation generally inconspicuous with the chromatophores relatively small, often distributed on the head, along the intestine, on the bases of the fin-rays or on the spinal cord, but so far not known to occur on the lateral body surface.

Two major groups immediately appear in the broad sorting of the muraenid leptocephali so characterised. Those specimens in which the dorsal fin, even in small examples, is long and originates a few segments behind, to many segments in advance of, the level of the vent, are referred to the *Gymnothorax–Rabula* group of genera. In the relatively young larvae of this group fin-rays are undeveloped, but the developing basal structures can usually be seen and counted; in more well developed specimens the dorsal origin may be well in advance of the level of the vent and the fin-rays may be easily counted; in specimens which are approaching metamorphosis and in still older specimens the dorsal origin is clearly defined and the fin-rays appear to have reached their full number. The bases of the anal fin-rays develop more slowly than do those of the dorsal but the definitive number is reached more rapidly than in the dorsal fin. Those specimens in which the dorsal and anal fins are restricted to the posterior tip of the body (so that they form, with the caudal fin, a small flap around the caudal tip), are referred to the *Uropterygius–Anarchias* group of genera. In this group the fin-rays of the dorsal are seldom greater in number than about 40 and the dorsal origin is only very slightly in advance of the level of the anal fin, which has about 30 or fewer fin-rays.

A more detailed examination of the leptocephali placed in the *Gymnothorax–Rabula* group reveals five further groups which are distinguished from one another mainly by regular differences in number and the pattern of distribution of chromatophores. Of these five "genera", one is much more frequently encountered in the collection, the number of specimens in this group amounting to half (56) of the total number of muraenid leptocephali. This group is referred to *Gymnothorax* Bloch, 1795 and is readily distinguishable from all others in having leptocephali with pigment distributed in a paired somatic series of chromatophores along the ventral body wall from the throat at least as far as the level of the gall bladder, a series of splanchnic chromatophores along the

pronephric ducts from the level of the gall bladder to the vent, an unpaired, mid-dorsal series in front of the dorsal origin and pigment on the spinal cord. In these respects the leptocephali of this group are similar to leptocephali of *Gymnothorax undulatus* and *G. hepaticus* as described by Ancona (1928, p. 75, p. 82) and to the muraenid leptocephalus described as Larva IV by Nair & Mohamed (1960, p. 211). Furthermore, within this *Gymnothorax* group the leptocephali more usually show the ventral, paired series of somatic chromatophores reaching from the throat only as far as the level of the gall bladder. There are six species which show this particular distribution of pigment. A few other larvae (referable to three species) in the *Gymnothorax* group have the ventral, paired series of chromatophores reaching to the vent. The two subdivisions of *Gymnothorax* noted here suggests that this large genus may contain two subgenera and may indeed support the separation of such forms as *Siderea* from *Gymnothorax* (as has been the practice of some authors).

The smaller group of muraenid larvae, in which the dorsal fin is long, contains four "genera". In all of these, somatic and splanchnic pigment along the intestine is largely absent although one shows an irregular scattering of chromatophores on the ventral body wall from the throat to the level of the gall bladder. In all of these there is always head pigment (distributed in various ways in the four "genera") and there may or may not be pigment on the spinal cord and on the dorsal and anal bases. One of these genera (*Rabula*) is tentatively identified on the basis of the characters shown by a single metamorphic specimen and another (*Echidna* Forster, 1777) on the nature of the dorsal fin.

Leptocephali which have the dorsal and anal fins reduced to rudiments at the caudal tip (and therefore possibly referable to two genera, *Uropterygius* and *Anarchias*) are in fact readily separable into two groups. The first of these (with three species) is characterised by having the body entirely devoid of pigment and is referred to the genus *Anarchias* on the basis of a single metamorphic specimen which shows a conspicuous cephalic sensory pore immediately behind the posterior nostril above the eye. The second group has pigment on the head, along the ventral body wall from the throat to the vent and in a mid-dorsal series in front of the dorsal origin (much as in *Gymnothorax*) and is referred to *Uropterygius*. The larvae of this group show in the amount and location of pigment two subdivisions (one with three species, the other with two) which are here suggested to represent possible subgeneric divisions of *Uropterygius*.

L. **Gymnothorax** sp. (121-128 myomeres), Text-fig. 1, A-E.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (13 specimens)*: 45.3mm total length, IFO Station P As 11, 17° 55′ S, 160° 37′ E, 13/5/58 (1859hrs), S1/2mO (0.5m net, no. 2 mesh, oblique tow), 0m–300m; 34.2, St D 15b, 9° 50′ S, 159° 20.5′ E, 22/5/60 (0219hrs), S1/2mO, 0m–300m; 39.9, St D 27b, 20° 26.5′ S, 163° 31′ E, 27/5/60 (2324hrs), S1/2mO, 0m–300m; 64.9, St MWT 3 I, 10 miles west of Bulari Pass, New Caledonia, 1/8/61, MWT3, H, ca. 40m, sample 4; 55.0, St S.1, 21° 45′ S, 165° 10′ E, 6/6/62, MWT5, H, ca. 120m; 46.2, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 44.5, St S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95m; 45.8, St S.7, 10° 48′ S, 159° 00′ E, 12/6/62, MWT5, H, ca. 95m; 49.3, St 7–1, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m; 55.2, 64.3, 68.0, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m; 65.0, St 7–9, 22° 35′ S, 166° 16′ E, 26/7/62, MWT5, H, ca. 85m.

C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (1 specimen): 67.8, *Fairwind*, Dugumur Bay, New Guinea, 22/12/48, submarine light and net.

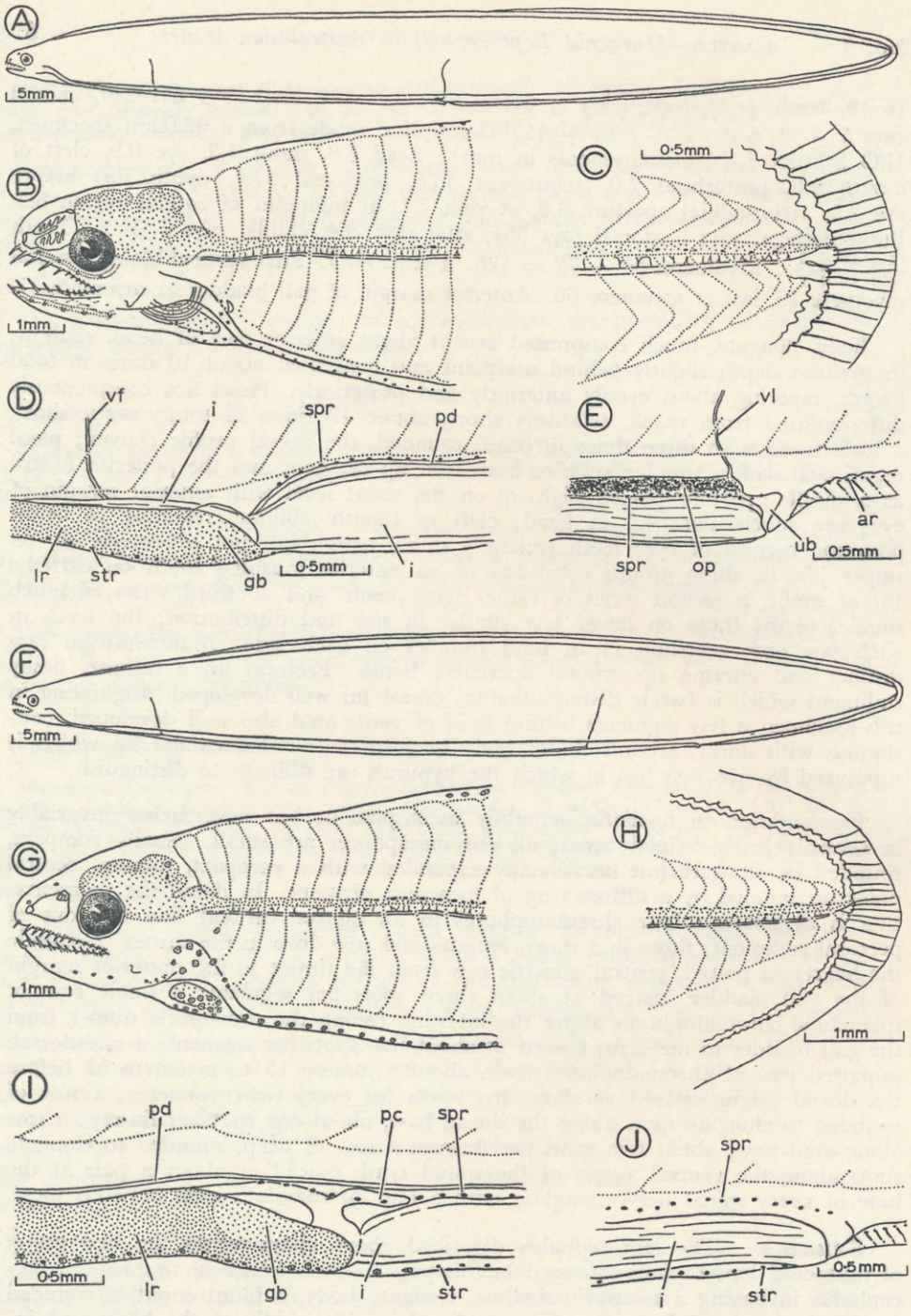
DESCRIPTION. 14 specimens: total lengths 34.2mm–68.0mm, myomeres 121–128 (52–64 + 64–73), first vertical blood vessel at myomere 16–18, last vertical blood vessel at myomere 57–59, anterior margin of gall bladder at myomere

16–19, teeth $\frac{1+IV+3-6}{1+IV-V+3-7}$, dorsal rays 356–371, anal rays 251–273, caudal rays 3 + 2, a–d = —7 to + 11. Description made from a 68.0mm specimen, IFO Station 7–2 (measurements in mm): head 3.9, snout 1.2, eye 0.9, cleft of mouth 1.8, postorbital 2.0, snout-vent 33.6, predorsal 37.1, depth just before eye 2.5, at branchial aperture 3.8, at vent 7.1, at midpoint of caudal region 6.5. Branchiostegal rays 9, dorsal rays 364, anal rays 264, caudal rays 3 + 2. Teeth $\frac{1+IV+6}{1+IV+7}$. Myomeres 54 + 72 = 126. a–d = — 7. First vertical blood vessel at myomere 16, last at myomere 56. Anterior margin of gall bladder at myomere 17.

Body elongate, much compressed except along anterior part of head, shallow, its greatest depth slightly behind midpoint and contained about 10 times in total length, tapering about evenly anteriorly and posteriorly. Head not conspicuously differentiated from trunk, relatively short, about 17 times in total; snout short, a little more than three times in head, rounded, the dorsal profile convex; nasal organ oval with a tubular anterior nostril on tip of snout and the posterior nostril as a simple aperture placed high up on the snout level with anterior margin of eye; eye subcircular; 4.3 in head; cleft of mouth oblique, reaching to below posterior margin of eye; teeth generally small, acute, but not excessively so, on upper jaw in three groups consisting of an anterior grasping tooth on extreme tip of snout, a second series of rather large teeth and a third series of much smaller teeth; those on lower jaw similar in size and distribution; the teeth in each jaw not exceeding 11 in total number on each side. Branchiostegal rays distinct and curving up around opercular bones. Pectoral fin a minute, fleshy rudiment which is barely distinguishable; dorsal fin well developed, originating in this specimen a few segments behind level of vent; anal also well developed, continuous with dorsal around tip of body to form a rounded caudal fin which is supported by five rays but in which the hypurals are difficult to distinguish.

Pigmentation in formalin generally inconspicuous but nevertheless invariably in several clearly-defined areas; all chromatophores are small, usually compact, rounded or elongate but occasionally expanded with a compact, minute, central point surrounded by a diffuse ring of brownish pigment. In detail the pigmentation is as follows: four chromatophores in an almost vertical line in front of pectoral rudiment; three in a short, longitudinal row deep in the throat (alongside the heart); a paired, ventral, somatic row from the throat to the posterior margin of the gall bladder, spaced at about three spots per segment; a single row of splanchnic chromatophores above the intestine (along the pronephric ducts) from the gall bladder to the vent, spaced at about five spots per segment; a mid-dorsal, unpaired row of chromatophores from about myomere 10 to myomere 57 before the dorsal origin, spaced at about five spots for every two myomeres; a row of rounded to elongate spots along the dorsal base, about one spot per fin-ray; a row along anal base, about two spots per fin-ray; a row of deep, rounded to elongate spots along the ventral aspect of the spinal cord, spaced at about a pair at the base of every spinal nerve ganglion with a few intermediate spots between these.

REMARKS. The leptocephalus described above characterises the first group of muraenid leptocephali discussed in this paper. It is a typical muraenid leptocephalus in having a relatively shallow, elongate body, a blunt snout, a rounded caudal fin, pectoral fin reduced, vent placed in the middle of the body and inconspicuous pigmentation. It also has a relatively well developed dorsal fin (although in the specimen described and illustrated the dorsal origin is slightly behind level of vent). It has intestinal pigment consisting of a paired, somatic row of spots below the intestine from the throat to the level of the gall bladder and an unpaired, splanchnic row above the intestine from the level of the gall bladder to the vent.



TEXT-FIG. 1.—Figs. A–E, *L. Gymnothorax* sp. (121–128 myomeres), 68.0mm total length, IFO Station 7–2: Fig. A—lateral view; Fig. B—lateral view of head; Fig. C—tip of caudal region; Fig. D—lateral view at level of gall bladder to show pigmentation along gut and pronephric ducts; Fig. E—lateral view at level of vent to show opisthonephros, urinary bladder and pigmentation. Figs. F–J—*L. Gymnothorax* sp. (131–137 myomeres), 71.0mm total length, *Fairwind* collection (New Guinea).

ABBREVIATIONS.—ar, row of chromatophores on bases of anal rays; gb—gall bladder; i—intestine; lr—liver; op—opisthonephros; pc—pyloric caecum; pd—pronephric duct; spr—row of splanchnic chromatophores along pronephric ducts; str—row of somatic chromatophores below intestine; ub—urinary bladder; vf—first vertical blood vessel; vl—last vertical blood vessel.

There have been about 25 different species of muraenid leptocephali described from the Indo-Pacific area, of which only four have been tentatively identified. A number of these previous descriptions, however, unfortunately lack sufficient detail with regard to the exact distribution of somatic and splanchnic pigment along the alimentary canal, where this occurs, for the species concerned to be compared with the present material. Amongst the 10 or more species which are known to have intestinal pigment I find none in which the distribution of this pigment exactly conforms with that described above, although *L. latus* Eigenmann & Kennedy, 1902, an Atlantic species, as figured by these authors (1902, fig. 6), shows intestinal pigment laterally and more widely spaced anteriorly than the more posterior dorsal and closely packed chromatophores. The majority, in contrast, have the paired, somatic row of chromatophores below the intestine extending along the whole length of the intestine from the throat to the vent (see Ancona, 1928, pp. 118–120; Nair & Mohamed, 1960, p. 19, etc., for details of these species) and can therefore be immediately referred to the second group of species described below in which pigment is distributed in a similar manner.

With regard to the further identification of this species, I am confident that it will eventually prove to be referable to *Gymnothorax* when sufficient metamorphic specimens are collected to show the continuity of larval and juvenile characters. In view of there being as many as 40 or 50 species of *Gymnothorax* in the Indo-Pacific whose vertebral counts are almost entirely unknown, specific identification at the present time cannot be achieved.

The smallest of the 14 specimens referred to this species (34.2mm) was collected in the Solomon Islands area (IFO Station D 15b) whilst the largest (67.8mm) was taken on the north-east coast of New Guinea (Dugumur Bay). Nearly full-grown specimens of over 60mm were also collected from close to the south-east end of New Caledonia. While there are too few specimens of this species in the present collection to show a clear-cut, progressive increase in size of larvae taken from the Solomons west to New Guinea and south to New Caledonia this is at least suggested here. A spawning area east of the Solomon Islands would be in accord with a suggested dispersal of larvae by way of the predominantly westward and south-westward trending current system in this area.

L. Gymnothorax sp. (103–109 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (15 specimens)*: 39.0mm total length, IFO Station 56–5–7, 12° 17′ S, 165° 26′ E, 4/11/56 (0000hrs), S1/2mH, ca. 100m; 36.7, St D 5, 18° 32′ S, 159° 50′ E, 14/5/60 (0820hrs), S1/2mO, 0m–300m; 29.2, St D 8, 17° 07′ S, 157° 47′ E, 15/5/60 (2003hrs), S1/2mO, 0m–300m; 44.5, St D 13b, 10° 49′ S, 158° 34′ E, 18/5/60 (1440hrs), S1/2mO, 0m–300m; 34.4, St MWT 3 I (sample 5), 10 miles west of Bulari Pass, New Caledonia, 1/8/61, MWT3, H, ca. 23m; 52.8, 60.0, St S.1, 21° 45′ S, 165° 10′ E, 6/6/62, MWT5, H, ca. 120m; 46.7, 46.7, St S.2, 20° 10′ S, 163° 27′ E, 7/6/62, MWT5, H, ca. 95m; 38.0, 38.3, 54.4, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 37.9, St S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95m; 27.8, St S.7, 1° 48′ S, 159° 00′ E, 12/6/62, MWT5, H, ca. 95m; 50.3, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION AND REMARKS. 15 specimens: total lengths 27.0mm–60.0mm, myomeres 103–109 (53–57 + 49–55), first vertical blood vessel at myomere 13–16, last at myomere 51–57, anterior margin of gall bladder at myomere 13–15, teeth $\frac{1 + \text{IV-V} + 2\text{-}4}{1 + \text{V-VI} + 2\text{-}3}$, dorsal rays 292–313, anal rays 192–213, caudal rays 3 + 2, a–d = + 6 to + 11.

This species shows a clear distinction from the one described above in having considerably fewer myomeres (with fewer postanally), the anterior margin of the gall bladder placed a few segments more anteriorly, fewer teeth in the posterior group on each jaw and fewer dorsal and anal rays. The pigmentation is in all respects similar.

The smallest specimen (27.8mm) of this species was collected as far north as about 2° S. (IFO Station S. 7) while specimens of less than 45mm were taken between 10° S. and 19° S. The largest specimens were taken in the area of New Caledonia (22° S.). The relative sizes of larvae of this species and their positions of capture are therefore not unlike those of the preceding species, at least suggesting a spawning area to the east of the Solomon Islands.

L. **Gymnothorax** sp. (115 myomeres).

MATERIAL EXAMINED. *Australian Museum Collection (1 specimen)*: 66.9mm total length, Aust. Mus. regd. no. IB.4512–IB.4515, Collaroy Beach, N.S.W., 21/11/59.

DESCRIPTION AND REMARKS. One specimen: myomeres 53 + 62 = 115, first vertical blood vessel at myomere 16, last at myomere 55, anterior margin of gall bladder at myomere 15, teeth absent, dorsal rays 266, anal rays 343, caudal rays 3 + 2, a–d = — 1.

This single specimen is intermediate in number of myomeres between the two preceding species and has less numerous dorsal but more numerous anal rays. Furthermore, it has a group of chromatophores scattered over the dorsal surface of the head, in addition to the pigment on the remainder of the body as described for these other species. I have no hesitation in regarding this specimen as a representative of a separate species, noting also that it is close to metamorphosis and was a beachcast specimen on the Australian coast.

L. **Gymnothorax** sp. (132–137 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (13 specimens)*: 21.0mm total length, IFO Station D 5b, 18° 32′ S, 159° 14′ E, 14/5/60 (1450hrs), S1/2mO, 0m–300m; 31.4, St Foa MWT (sample 1), 22° 20′ S, 165° 42′ E, 10/1/62, MWT3, H, ca. 100m; 57.9, 60.3, 61.4, St S.2, 20° 10′ S, 163° 27′ E, 7/6/62, MWT5, H, ca. 95m; 35.1, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 37.2, St S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95m; 58.0, St S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m; 42.6, St S.9, 15° 42′ S, 162° 20′ E, 21/6/62, MWT5, H, ca. 95m; 66.9, St 7–1, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m; 68.3, 71.8, St 7–4, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 35m; 59.3, St 7–9, 22° 35′ S, 166° 16′ E, 26/7/62, MWT5, H, ca. 85m.

Australian Museum Collection (1 specimen): 82.1, Aust. Mus. regd. no. IB.4512–IB.4515, Collaroy Beach, N.S.W., 21/11/59.

Western Australian Museum Collection (1 specimen): 69.9, Acc. No. P5181, *Lancelin*, 27 miles west of West End, Rottnest Island, Western Australia, 31/7/61 (1945–2015hrs), N70, surface.

DESCRIPTION AND REMARKS. 15 specimens: total lengths 21.0mm–82.1mm, myomeres 132–137 (59–85 + 48–77), first vertical blood vessel at myomere 16–18, last at myomere 61–76, anterior margin of gall bladder at myomere 19–21, teeth $\frac{1 + \text{II-IV} + 3\text{-}5}{1 + \text{III-VI} + 2\text{-}4}$ (absent in the largest specimen), dorsal rays 339–416, anal rays 226–325, caudal rays 3 + 2, a–d = — 4 to + 36.

In the total number of myomeres and distribution of pigment along the gut this species closely resembles *L. latus* Eigenmann & Kennedy, 1902 (from the Atlantic). The latter has 133 myomeres (98 + 35) but has a patch of chromatophores on the dorsal surface of the head, and in view of the fact that minor differences in pigmentation may be of specific value as well as differences in myomere

number, position of vessels, gall bladder, etc., it would be unwise to refer the present larva to Eigenmann & Kennedy's species. More significantly, the number of muraenid species which are common to both the Atlantic and Indo-Pacific is extremely small compared with the total number of species in this genus and even those that are, occur only in the South African area. Without specimens of *L. latus* in hand I would hesitate to refer the present material to this species.

All specimens in this group were collected south of the Solomon Islands, with the smallest (21.0mm) taken north-west of New Caledonia and the largest individuals (over 60mm) close to the southern end of New Caledonia. A very large metamorphic specimen was beach cast on the New South Wales coast. Again a spawning area north of New Caledonia is indicated, but further small specimens are necessary to confirm this suggestion. The species possibly spawns also off the West Australian coast.

L. Gymnothorax sp. (143–144 myomeres).

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (2 specimens)*: 81.1mm total length, *Fairwind,* Kieta (Bougainville Island, Solomon Islands), 21/10/49, submarine light; 80.1, *Fairwind,* Sohana (Buka Passage, Bougainville Island, Solomon Islands), 25/10/49, submarine light.

DESCRIPTION AND REMARKS. Two specimens: myomeres 143–144 (79–80 + 64), first vertical blood vessel at myomere 19–20, last at myomere 72–73, anterior margin of gall bladder at myomere 21–22, teeth absent in both specimens, dorsal rays 324–331, anal rays ca. 220–236, caudal rays 3 + 2, a–d = + 16 to + 19.

The two specimens listed above are metamorphic larvae, having an opaque body which is oval and not rounded in section, teeth absent and an anterior origin to the dorsal. There are no conspicuous differences which make these leptocephali distinguishable from the preceding species except in the number of myomeres, this number being appreciably more than in the latter.

In common with a number of other leptocephali collected by the *Fairwind* in the New Guinea area, these two are metamorphic larvae which may have travelled some distance from their spawning area.

L. Gymnothorax sp. (155 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 47.2mm total length, IFO Station 7–1, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION AND REMARKS. One specimen: myomeres 65 + 90 = 155, first vertical blood vessel at myomere 17, last at myomere 64, anterior margin of gall bladder at myomere 21, teeth $\frac{1 + IV + 3}{1 + V + 2}$, dorsal rays 356, anal rays 310, caudal rays 3 + 2, a–d = + 3.

This single specimen has the highest number of myomeres within the present group of species, and on this basis I am confident that it represents a distinct species.

L. Gymnothorax sp. (131–137 myomeres), Text-fig. 1, F-J.

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (3 specimens)*: 68.5mm total length, *Warreen* Station 223/39, 35° 05′ S, 151° 36′ E, 2/10/39, N70, O, 200m; 71.0, *Fairwind,* Kieta (Bougainville Island, Solomon Islands), 21/10/49, submarine light; 74.5, *Fairwind,* Wewak Harbour, New Guinea, 23/11/49, submarine light.

Australian Museum Collection (3 specimens): 63.8, Aust. Mus. regd. no. IA.6893, Maroubra, N.S.W., 24/5/36; 67.2, Aust. Mus. regd. no. IB.4237, Collaroy Beach, N.S.W., 15/4/59; 64.3, Aust. Mus. regd. no. IB.4238, Collaroy Beach, N.S.W., 15/4/59.

DESCRIPTION. Six specimens: total lengths 63.8mm–74.5mm, myomeres 131–137, first vertical blood vessel at myomere 15–17, last at myomere 69–81, anterior margin of gall bladder at myomere 20–22, teeth $\frac{1 + \text{IV-VI} + 4\text{-}6}{1 + \text{IV} + 3\text{-}5}$ (absent in the largest specimen), dorsal rays 359–377, anal rays 224–257, caudal rays 3 + 2, a–d = + 12 to + 73. Description made from a 71.0mm specimen from *Fairwind* collection (measurements in mm): head 3.9, snout 1.3, eye 0.8, cleft of mouth 2.0, postorbital 2.0, snout-vent 54.8, predorsal 14.3, depth just before eye 2.6, at branchial aperture 3.7, at vent 7.9, at midpoint between branchial aperture and vent 9.5. Dorsal rays 359, anal rays 224, caudal rays 3 + 2. Teeth $\frac{1 + \text{VI} + 6}{1 + \text{VII} + 3}$. Myomeres 96 + 39 = 135. a–d = + 73. First vertical blood vessel at myomere 17, last at myomere 81. Anterior margin of gall bladder at myomere 22.

Body elongate, much compressed except along head region, moderately shallow, its greatest depth a little behind midpoint where it is contained about 7.5 times in total length, tapering a little more gradually in front of this point than behind it. Head moderately differentiated from trunk, short, about 18 in total length; snout short, about three times in head, rather blunt, its dorsal profile convex; nasal organ oval with the anterior nostril tubular on tip of snout, the posterior nostril a simple, wide aperture placed above the horizontal diameter of eye and appreciably in advance of anterior margin of eye; eye subcircular, relatively small, about five times in head; cleft of mouth oblique, reaching to below posterior margin of eye; teeth generally small, relatively acute, in three groups on each side as follows: along the upper jaw an anterior grasping tooth, six large, prominent teeth and posteriorly six smaller teeth; those of lower jaw similar in size and distribution. Pectoral fin absent; dorsal fin well developed and in this specimen its origin well forward shortly behind head; anal fin also well developed and both fins confluent around caudal tip to form a rounded caudal which is supported by five rays.

Pigmentation in formalin generally inconspicuous to the naked eye but on close examination invariably in a number of clearly defined areas; in this specimen at least, most chromatophores consisting of a compact, minute central point surrounded by a diffuse ring of brownish pigment. In detail the pigmentation is as follows: two rather deep chromatophores on the temporal region (cerebellum); seven in a rounded group on the opercular region; about five in a line on the anterior part of the throat but obscured by the free angle of the lower jaw; two longitudinal rows of six chromatophores each on the lateral surface of the throat; an unpaired, somatic, ventral row from the throat to the level of the gall bladder, the chromatophores alternating for most of this row to give the impression of two rows spaced at about four pigment spots per myomere; an unpaired, ventral, row of somatic chromatophores from the level of the gall bladder to the vent, spaced at about one spot per myomere; an unpaired, splanchnic row of rounded chromatophores above the intestine (along the pronephric ducts) from the anterior margin of the gall bladder, about three per myomere, to the vent; a short, unpaired, somatic row from myomere 11 to the dorsal origin along the dorsal midline, spaced at about two chromatophores per myomere; a row of minute chromatophores along the dorsal base (two spots per ray) and a row along the anal base (one spot per ray); a row along the dorsal aspect of the spinal cord from about the 9th myomere to the caudal tip, 2–3 spots per myomere; two or three flattened chromatophores on the ventral aspect of the spinal cord at the posterior caudal tip.

REMARKS. In having the paired, ventral row of somatic chromatophores extending from the throat to the vent the species described above is readily distinguished from the six species in the first group of leptocephali discussed here. In this respect the present species can be referred to Group XIII (Muraenidae) of Ancona (1928, p. 118) which includes (with the notable exceptions of *L. grassianus* Ancona, 1928 and *L. vermicularis* Southwell & Prashad, 1919) muraenid leptocephali.

The present species has about 96 preanal myomeres in a total of about 131–137 and therefore can be initially referred to *L. latus* Eigenmann & Kennedy, 1902 if not to *L. Gymnothorax unicolor* Regan in Ancona's key. However, these are Atlantic species, and I would therefore more confidently refer the present species close to *L. Gymnothorax undulatus* Lacépède, 1803 which has 125–131 myomeres or to Species E (Gopinath, 1950, p. 89) or Species II & III (Pantalu & Jones, 1952, p. 30).

The six specimens are all full-grown or metamorphic individuals.

L. Gymnothorax sp. (153 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 38.1mm total length, IFO Station S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m.

DESCRIPTION AND REMARKS. One specimen: myomeres 96 + 57 = 153, first vertical blood vessel at myomere 17, last at myomere 85, anterior margin of gall bladder at myomere 23, teeth $\frac{1+V+4}{1+V+2}$, dorsal rays 395, anal and caudal rays not well enough developed to be counted, a–d = + 49.

This species bears strong resemblances to *L. muraenoides* Ancona, 1928 which has 147 myomeres (89 + 58) and similar pigmentation. It is, however, clearly referable to *Gymnothorax*, but its final identification must await an examination of members of this genus for vertebral counts.

L. Gymnothorax sp. (166 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 71.8mm total length, IFO Station D 10b, 14° 13′ S, 157° 55′ E, 17/5/60 (0214hrs), S1/2mO, 0m–300m.

DESCRIPTION AND REMARKS. One specimen: myomeres 110 + 56 = 166, first vertical blood vessel at myomere 18, last at myomere 103, anterior margin of gall bladder at myomere 25, teeth $\frac{1+V+7}{1+VI+5}$, dorsal rays 431, anal rays 257, caudal rays 3 + 2, a–d = + 65.

This relatively large muraenid leptocephalus has the most numerous myomeres within the whole group of species discussed in this paper. It has very numerous dorsal rays and posteriorly placed last vertical blood vessel and gall bladder. The dorsal origin is forwardly placed, although the specimen shows no other sign of metamorphosis. The specimen shows close resemblances to *L. Gymnothorax hepaticus* Rüppell, 1828 which, as described by Ancona (1928, p. 82) has 158–162 myomeres and similar pigmentation.

L. ?Rabula sp. (104–109 myomeres), Text-fig. 2, A-C.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (2 specimens)*: 49.9mm total length, IFO Station S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m; 51.7, St 7–3, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 35m.

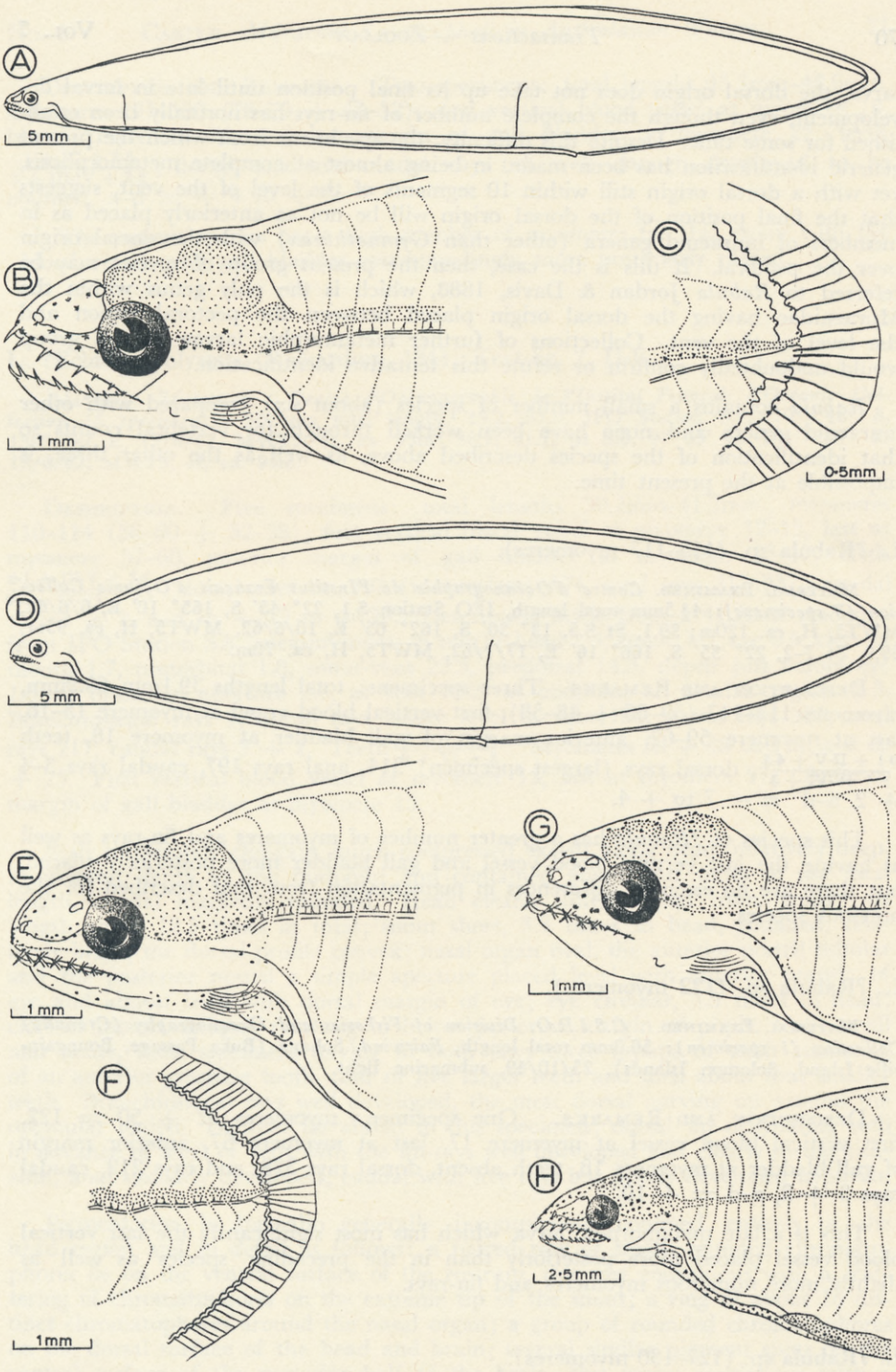
DESCRIPTION. Two specimens: total lengths 49.9mm–51.7mm, myomeres 104–109 (66–67 + 37–43), first vertical blood vessel at myomere 15–16, last at myomere 57, anterior margin of gall bladder at myomere 15–16, teeth $\frac{1 + \text{III-IV} + 3\text{-}4}{1 + \text{IV-V} + 3}$, dorsal rays 240–247, anal rays 165–170, caudal rays 3 + 2, a–d = + 3 to + 6. Description made from the larger specimen (measurements in mm): head 3.4, snout 1.1, eye 1.0, cleft of mouth 1.6, postorbital 1.4, snout-vent 33.9, predorsal 33.2, depth just before eye 2.0, at branchial aperture 3.1, at vent 8.8, at midpoint between branchial aperture and vent 7.3. Dorsal rays before level of vent ca. 32. Myomeres 66 + 43 = 109.

Body elongate, much compressed except along head region, relatively deep, its greatest depth behind midpoint where it is contained about six times in total length, tapering more rapidly behind this point. Head poorly differentiated from trunk, relatively short, about 15 in total; snout short, three times in head, rounded, but not excessively so, its dorsal profile slightly convex; nasal organ oval with the anterior nostril tubular on tip of snout and the posterior nostril a simple aperture placed level with anterior margin of eye and high up on snout; eye circular, 3.4 in head; cleft of mouth oblique, extending to below posterior margin of pupil; teeth relatively small and acute, in both jaws in three groups consisting of an anterior grasping tooth, three or four larger teeth and three or four smaller teeth, the two posterior groups in the lower jaw not as clearly defined from one another as those of the upper jaw and the teeth on each side in both jaws never exceeding 10 in number. Branchiostegal rays well developed, 10 in number. Pectoral fin a minute, fleshy rudiment; dorsal fin in this specimen originating a few segments in advance of level of vent and the rays poorly developed with the number as given above probably incomplete; anal fin similarly developed; hypurals difficult to distinguish.

Pigmentation in formalin generally inconspicuous, restricted mainly to head and anal fin and in detail as follows: a confluent group of irregularly-shaped chromatophores lie on the ventral aspect of the rostrum; several around nasal organ, either on the surface or deep; four or five relatively large chromatophores deep on the ventral surface of the posterior half of the brain; a number of small surface chromatophores behind the eye; along caudal region about one minute, rounded chromatophore on each side of each spinal nerve ganglion on ventral aspect of spinal cord; a minute chromatophore at the base of each anal ray and at the base of the last 20 dorsal rays.

REMARKS. This species, in common with the three others of this group described below, is immediately distinguished from larvae of species of *Gymnothorax* in having pigment absent from along the intestine but profusely present on the head region as well as on the posterior part of the spinal cord and along the dorsal and anal base. The dorsal fin, even in specimens relatively far advanced in metamorphosis, never originates further than about 10 segments in front of the level of the vent and more usually lies close to this level. Although the present species shows no definitive character or characters by which, from present knowledge it may be referred to a muraenid genus, there is a single specimen in the present group (see below as *Rabula* sp., 122 myomeres) which possibly has such a character. The latter specimen has thus been used as a basis for the tentative generic identification of the three other species in the group.

The single definitive character is the position of the dorsal origin. This is known to be variable in the leptocephali of the majority of eels, depending greatly upon the age of the larva. In most species in which the dorsal origin has an anterior position (for example, over the pectoral region) in the metamorphosed



TEXT-FIG. 2.—Figs. A–C, *L. ?Rabula* sp. (104–109 myomeres), 51.7mm total length, IFO Station 7–3: Fig. A—lateral view; Fig. B—lateral view of head; Fig. C—tip of caudal region. Figs. D-F, *L. ?Echidna polyzona* (Richardson, 1844), 41.2mm total length, IFO Station S.8. Fig. G—*L. ?Muraena pardalis* Schlegel, 1847, or *L. ?Enchelynassa canina* Quoy & Gaimard, 1824, 38.0mm total length, IFO Station S.5; lateral view of head. Fig. H, *L. Muraena pardalis* Schlegel, 1847 or *L. ?Enchelynassa canina* Quoy & Gaimard, 1824, 62.2mm total length, IFO Station 7–2; lateral view of head.

larva, the dorsal origin does not take up its final position until late in larval development, even though the complete number of fin-rays has normally been established for some time. Despite this difficulty, the specimens from which the present generic identification has been made, in being almost at complete metamorphosis, yet with a dorsal origin still within 10 segments of the level of the vent, suggests that the final position of the dorsal origin will be not as anteriorly placed as in members of muraenid genera (other than *Gymnothorax*) with the dorsal origin over the pectoral. If this is the case, then the present group of species may be referred to *Rabula* Jordan & Davis, 1888, which is the only genus within the Muraenidae having the dorsal origin placed between the pectoral region and the level of the vent. Collections of further metamorphic larvae of this group would undoubtedly confirm or refute this tentative identification.

Rabula contains a small number of species (about six) compared with other muraenid genera and none have been worked through for vertebral counts so that identification of the species described above, as well as the other three, is impossible at the present time.

L. ?Rabula sp. (115–117 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (3 specimens)*: 44.5mm total length, IFO Station S.1, 22° 45′ S, 165° 10′ E, 6/6/62, MWT5, H, ca. 120m; 39.1, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 69.9, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION AND REMARKS. Three specimens: total lengths 39.1mm–69.9mm, myomeres 115–117 (59–66 + 48–58), first vertical blood vessel at myomere 15–16, last at myomere 59–62, anterior margin of gall bladder at myomere 18, teeth $\frac{0\text{-}1 + II\text{-}V + 4\text{-}5}{1 + IV\text{-}VI + 3}$, dorsal rays (largest specimen) 314, anal rays 197, caudal rays 3–4 + 2, a–d = — 7 to + 4.

This species of *?Rabula* has a greater number of myomeres and fin-rays as well as having the last vertical blood vessel and gall bladder more posteriorly placed, but there are no essential differences in pigmentation from that described for the previous species.

L. ?Rabula sp. (122 myomeres).

MATERIAL EXAMINED. *C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (1 specimen)*: 56.0mm total length, *Fairwind*, Sohana (Buka Passage, Boungainville Island, Solomon Islands), 25/10/49, submarine light.

DESCRIPTION AND REMARKS. One specimen: myomeres 72 + 50 = 122, first vertical blood vessel at myomere 17, last at myomere 67, anterior margin of gall bladder at myomere 18, teeth absent, dorsal rays 328, and rays 212, caudal rays 3 + 2, a–d = + 10.

This is a late metamorphic larva which has most significantly the last vertical blood vessel placed more posteriorly than in the preceding species as well as slightly more numerous myomeres and fin-rays.

L. ?Rabula sp. (127–130 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (2 specimens)*: 45.3mm total length, IFO Station P58–1–10(45–2), 21° 10′ S, 166° 45′ E, 20/1/58 (0045hrs), S1/2mH, 50m; 48.6, St Foa 1m (sample 6), 20° 00′ S, 163° 13′ E, 12/1/62, S1mO, ca. 167m.

DESCRIPTION AND REMARKS. Two specimens: total lengths 45.3mm–48.6mm, myomeres 127–130 (78–79 + 48–52), first vertical blood vessel at myomere 18, last at myomere 70, anterior margin of gall bladder at myomere 22, teeth $\frac{1 + III + 2\text{-}3}{1 + III\text{-}IV + 2\text{-}3}$, dorsal, anal and caudal rays not well enough developed to be counted, a–d = + 4 to + 5.

The present species has a high number of myomeres for this group with the blood vessels and gall bladder correspondingly more posteriorly placed.

L. ?Echidna polyzona (Richardson, 1844) Text-fig. 2, D-F.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (5 specimens)*: 30.7mm total length, 35.2, 37.9, IFO Station S.7, 10° 48′ S, 159° 00′ E, 12/6/62, MWT5, H. ca. 95m; 38.7, 41.2, St S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m.

DESCRIPTION. Five specimens: total lengths 30.7mm–41.2mm, myomeres 110–114 (56–60 + 52–58), first vertical blood vessel at myomere 12–15, last at myomere 57–60, anterior margin of gall bladder at myomere 13–17, teeth $\frac{0\text{-}1 + IV\text{-}V + 3\text{-}6}{0\text{-}1 + IV\text{-}VI + 2\text{-}4}$, dorsal rays ca. 302 (incomplete)–374, anal rays 217–237, caudal rays 3 + 2, a–d = + 22 to + 29. Description made from a 41.2mm specimen from IFO Station S.8 (measurements in mm): head 3.3, snout 1.0, eye 0.9, cleft of mouth 1.7, postorbital 1.8, snout-vent 22.5, predorsal 14.3, depth just before eye 1.6, at branchial aperture 2.9, at vent 10.2, at midpoint of caudal region 8.3. Branchiostegal rays 9, dorsal rays before level of vent 180, dorsal rays 371, anal rays 217, caudal rays 3 + 2. Teeth $\frac{0 + V + 5}{0 + VI + 3}$. Myomeres 56 + 58 = 114, a–d = + 25. First vertical blood vessel at myomere 13, last at myomere 57. Anterior margin of gall bladder at myomere 15.

Body moderately elongate, much compressed except along head, relatively deep, its greatest depth at the midpoint and contained about four times in the total length, caudal markedly rounded. Head clearly differentiated from trunk, its length about 12.5 times in total; snout short, 3.3 times in head, rounded, relatively blunt, the dorsal profile convex; nasal organ oval, the anterior nostril tubular and the posterior nostril a simple aperture placed level with anterior margin of eye and almost level with dorsal margin of eye; eye circular, 3.5 times in head; cleft of mouth oblique, reaching to below posterior margin of pupil; teeth small and acute, most specimens having in both jaws three groups of teeth consisting of an anterior grasping tooth, four or five larger teeth and then about four smaller teeth. Branchiostegal rays well developed, the most dorsal curving up around the opercular region. Pectoral fin absent in this specimen; dorsal fin originating well in advance of level of vent with the fin-rays well developed and clearly distinguishable; anal similarly developed; caudal with five rays but poorly developed hypurals.

Pigmentation in formalin generally inconspicuous, confined entirely to the head region and in detail as follows: a paired row of small, rounded chromatophores lie on the ventral surface of the rostrum, this row continuous with a scattering of chromatophores on the extreme tip of the snout; a ring of about 16 distinct chromatophores around the nasal organ; a group of rounded chromatophores on the dorsal surface of the head and brain; several similar pigment spots on the ventral surface of the posterior half of the brain, this group continuous with a number of chromatophores on the lateral surface of the head at this level and with a group on the opercular region; numerous spots on the ventral aspect of the throat, extending to the posterior margin of the heart.

REMARKS. The present species, together with the two others (below) in this group, superficially resembles the species of *?Rabula* described above. Pigment is restricted to the head and there is no pigment along the intestine, but in addition chromatophores are scattered over the throat and lower jaw, while pigment is absent from the spinal cord and bases of the dorsal and anal fins. Perhaps more conspicuously, the dorsal origin is always well in advance of the level of the vent so that it lies between 22 and 48 segments in front of this level (although in very small specimens of less than 25mm, of which there are no specimens in the present collection, the dorsal origin would probably be indefinite and behind the level of the vent). This indicates to me that the three species under discussion probably belong to a muraenid genus which is characterised in its metamorphosed form by an anterior dorsal origin, over the branchial region. There remain, after *Gymnothorax*, a number of other muraenid genera which possess this character. The most well-known and widespread in the Indo-Pacific of these is *Echidna* Forster, 1777 with about six species in this area, of which *E. nebulosa* (Ahl, 1789), *E. zebra* (Shaw, 1797) and *E. polyzona* (Richardson, 1844) are the best known. The other genera are *Rhinomuraena* Garman, 1888 (with its single species *R. quaesita* Garman, 1888), *Enchelynassa* Kaup, 1855 (a single species *E. canina* (Quoy & Gaimard, 1824)), *Pseudechidna* Bleeker, 1863 (a single species *P. brummeri* (Bleeker, 1858–59)), *Thyrsoidea* Kaup, 1856 (a single species *T. macrura* (Bleeker, 1854)) and *Muraena* L. (one species, *M. pardalis* (Schlegel, 1864)). *Rhinomuraena, Pseudechidna* and *Thyrsoidea* are all very elongate morays which probably have very numerous vertebrae and would not seem to be the parent form of the present species. The leptocephalus of *Thyrsoidea macrura* has already been characterised (Nair, 1947, p. 8, figs. 7–11, pl. 2, figs. 1–2). This leaves the two genera *Enchelynassa* and *Muraena*, both of which are known to have one species only in the Pacific, so that in view of the presence of three species in the group of leptocephali under discussion here a tentative identification of this group with *Echidna*, is suggested. In possible support of this identification are comparative myomere counts in the two species of *Echidna* which have been examined for this character, and in the three species of leptocephalus described here. *E. nebulosa* has 122 vertebrae, *E. zebra* has 135 (see Ancona, 1928, p. 10) while the number of myomeres in the leptocephali are 110–114, 124 and 135 respectively. Of particular interest is that *E. zebra* has the vent placed much more posteriorly (near the beginning of the last third of the body) than in the other two species (which have the vent about in the middle of the body). This is reflected in *E. zebra* having 97 + 38 vertebrae while *E. nebulosa* has 65 + 57. The three species of leptocephalus have preanal and postanal myomeres as follows: 56–60 + 52–68, 68 + 56 = 124 and 85 + 50 = 135. While reliance on these figures as a means of identification should not be overly stressed, I would on the basis of all these features tentatively identify the two species described below as *E. nebulosa* and *E. zebra* respectively. The species described above may eventually prove to be the third species of *Echidna, E. polyzona.* A simple check on the number of vertebrae in the adult of this species could easily confirm or refute this identification.

L. ?Echidna nebulosa (Ahl, 1789)

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 41.7mm total length, IFO Station S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95m.

DESCRIPTION AND REMARKS. One specimen: myomeres 68 + 56 = 124, first vertical blood vessel at myomere 14, last at myomere 65, anterior margin of gall bladder at myomere 17, teeth $\frac{1+V+3}{1+IV+3}$, dorsal rays 386, anal rays 250, caudal rays 3 + 2, a–d = + 40.

This species has the last vertical blood vessel placed more posteriorly and has slightly more numerous fin-rays than the preceding species.

L. ?Echidna zebra (Shaw, 1797)

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 45.0mm total length, IFO Station 56–4–12, 1° 10′ S, 176° 40′ E, 14/10/56 (0001hrs), S1/2mH, ca. 30m.

DESCRIPTION AND REMARKS. One specimen: myomeres 85 + 50 = 135, first vertical blood vessel at myomere 16, last at myomere 80, anterior margin of gall bladder at myomere 17, teeth $\frac{1 + IV + 4}{1 + IV + 3}$, dorsal rays 399, anal rays poorly developed, caudal rays 3 + 2, a–d = + 48.

The most conspicuous feature of this species is the posteriorly placed last vertical blood vessel compared with its position in the preceding two species. There are conspicuously more numerous preanal myomeres in this specimen than in individuals of the other species.

L. ?Muraena pardalis Schlegel, 1847 or

L. ?Enchelynassa canina Quoy & Gaimard, 1824, Text-fig. 2, G.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 38.0mm total length, IFO Station S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m.

DESCRIPTION. One specimen (measurements in mm): head 3.2, snout 1.0, eye 0.9, cleft of mouth 1.7, postorbital 1.5, snout-vent 27.6, predorsal ca. 19.0, depth just before eye 1.5, at branchial aperture 2.8, at midpoint between branchial aperture and vent 6.9, at vent 6.4. Branchiostegal rays 8, dorsal, anal and caudal rays not well enough developed to be counted. Teeth $\frac{1 + III + 3}{1 + IV + 1}$. Myomeres 88 + 55 = 143, a–d = ca. + 49. First vertical blood vessel at myomere 17, last at myomere 82. Anterior margin of gall bladder at myomere 17.

Body elongate, much compressed except along anterior part of head, its greatest depth at about the midpoint and contained 5.5 times in total length, tapering about evenly in front of, and behind, this point. Head short, about 12 times in total; snout short, 3.2 times in head, rounded, the dorsal profile convex; nasal organ oval with the two nostrils clearly separated; eye subcircular, 3.5 in head; cleft of mouth oblique, reaching to below posterior margin of eye; teeth on each jaw in three groups, the anterior one of a single tooth, the second of three or four teeth and the most posterior consisting of one and three much smaller teeth. Branchiostegal rays barely visible but able to be counted, curving up around opercular bones. Pectoral fin absent; dorsal fin just visible, its origin at about the level of the 40th myomere, but the rays not developed; anal similarly developed; caudal rounded.

Pigmentation inconspicuous, restricted to about ten chromatophores on the underside of the rostrum, a scattering of rounded spots over the brain, above the branchial region and above the anterior upward curvature of the intestine with three minute spots on the tips of the hypurals.

REMARKS. This leptocephalus is very similar in amount and distribution of pigment to those described for *?Echidna* but differs in having no chromatophores on the lower jaw and throat. Until further specimens become available so that this difference may be evaluated in greater detail, I suggest that this species be regarded as generically distinct from the preceding three species. As has already

been pointed out above, the remaining genera in the Muraenidae which have an anterior dorsal origin as well as having a short body with probably a moderate number of vertebrae are *Muraena* and *Enchelynassa* (compared with *Rhinomuraena, Pseudechidna* and *Thyrsoidea*). The leptocephalus of *Muraena helena* (L.), the Atlantic representative of *Muraena*, has apparently been described by Grassi (1910), but as this reference has not been available to me I am unable to state whether or not the present leptocephalus conforms generically with that of *M. helena*.

L. ?**Muraena pardalis** Schlegel, 1847 or

L. ?**Enchelynassa canina** Quoy & Gaimard, 1824, Text-fig. 2, H.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 62.2mm total length, IFO Station 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION. One specimen (measurements in mm): head 4.7, snout 1.5, eye 1.1, cleft of mouth 2.4, postorbital 2.2, snout-vent 41.4, predorsal 20.8, depth just before eye 1.2, at branchial aperture 4.2, at midpoint between pectoral and vent 11.6, at vent 11.5. Dorsal rays 418, anal rays 236, caudal rays 3 + 2. Teeth $\frac{1 + VI + 5}{1 + VI + 6}$. Myomeres 84 + 61 = 145. a–d = + 48. First vertical blood vessel at myomere 17, last at myomere 80. Anterior margin of gall bladder at myomere 19.

Body elongate-oval, much compressed except along head region, relatively deep, its maximum depth about 5.4 times in the total. Head noticeably differentiated from trunk, relatively short, about 13 times in the total; snout short, contained about three times in head length, not conspicuously rounded but with the dorsal profile convex; nasal organ oval with distinct anterior and posterior nostrils; eye subcircular, a little more than four times in head length; cleft of mouth oblique, reaching to below posterior margin of eye; teeth in three groups of which the first on the upper jaw consists of a single grasping tooth, the second of six larger teeth and the third of five much smaller teeth; those on the lower jaw similar in size and grouping. Branchiostegal rays not well enough developed to be counted. Pectoral fin absent; dorsal fin well developed with clearly observable fin-rays and a definite origin well in advance of the level of vent; anal similarly well developed; caudal rounded.

Pigmentation inconspicuous but characteristic, as follows: snout, brain, branchial region, throat and anterior upward curvature of intestine profusely covered with rounded to irregular chromatophores; from the throat to the level of the 14th myomere a ventral scattering of four irregular rows of somatic chromatophores; four minute pigment spots on the posterior tip of the vertebral column; about six small chromatophores on the tip of the hypurals and the bases of the terminal anal rays.

REMARKS. In having the profuse head and conspicuous anterior intestinal pigment this leptocephalus is immediately distinguished from all other muraenid leptocephali. However, further than suggesting that this species is referable to either *Muraena* or *Enchelynassa* I am not able to conclusively identify this larva.

L. **Anarchias** sp. (96-111 myomeres), Text-fig. 3, A-C.

1934. Larva IX Deraniyagala, *Ceylon J. Sci.*, 19 B(1): 96, fig. 11.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (5 specimens)*: 32.7mm total length, IFO Station 56–2–10, 22° 00′ S, 165° 50′ E, 24/4/56 (1320hrs), S1/2mH, ca. 70m; 29.2, St D 8, 17° 07′ S, 157° 47′ E, 15/5/60 (2003hrs), S1/2mO, 0m–300m; 38.7, St D 17, 10° 18′ S, 160° 42′ E, 22/5/60 (2022hrs), S1/2mO, 0m–300m; 55.9, 60.8, St MWT 1, 22° 40′ S, 167° 20′ E, 21/12/61, MWT3, H, ca. 100m.

Western Australian Museum Collection (1 specimen): 56.0, Acc. No. P5248, *Lancelin*, 50 miles west of West End, Rottnest Island, Western Australia, 9/5/62, larval net, 37m.

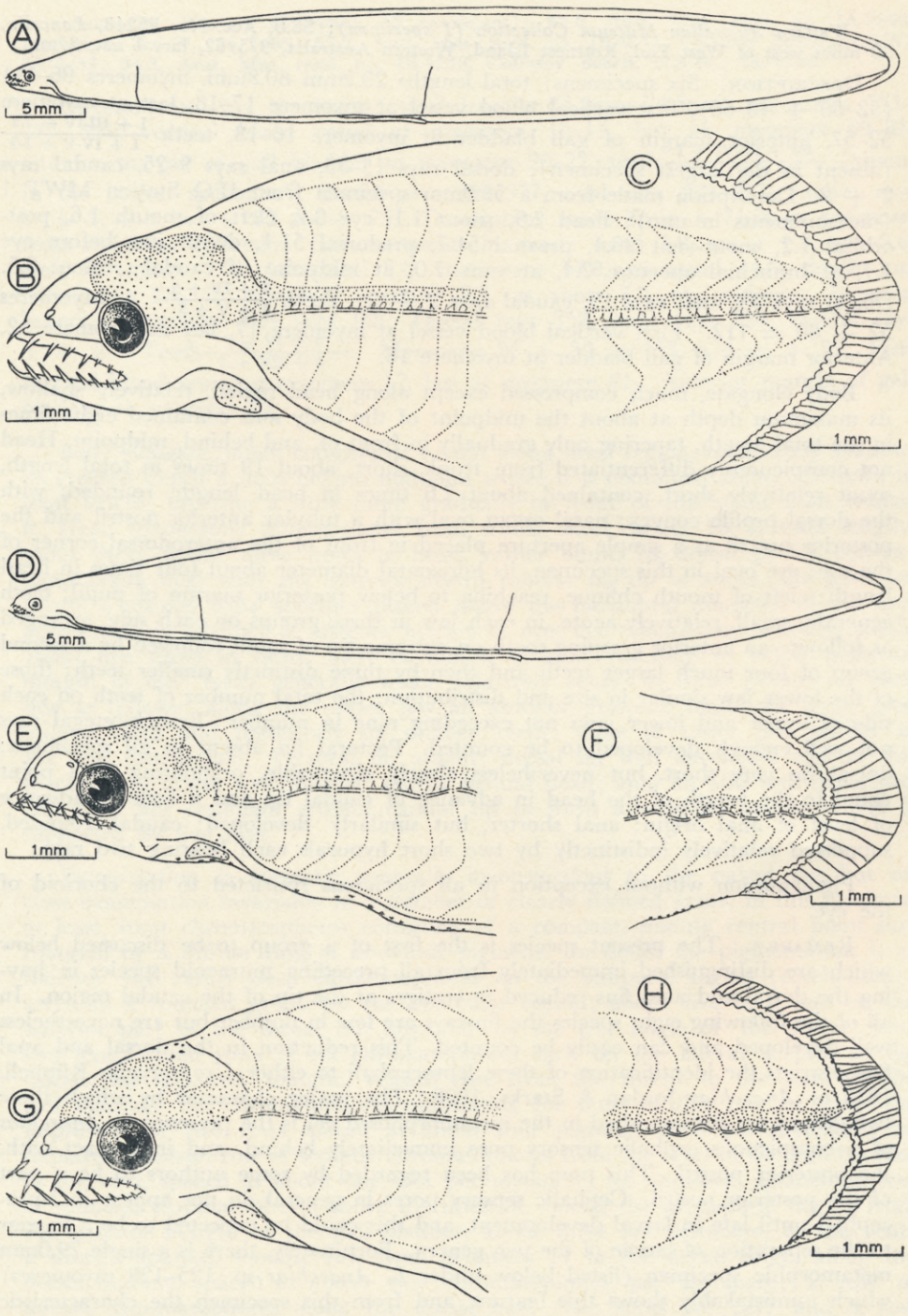
DESCRIPTION. Six specimens: total lengths 29.2mm–60.8mm, myomeres 96–111 (52–60 + 40–60), first vertical blood vessel at myomere 17–18, last at myomere 52–57, anterior margin of gall bladder at myomere 16–18, teeth $\frac{1 + \text{III-IV} + 2\text{-}3}{1 + \text{IV-V} + 1\text{-}3}$ (absent in the largest specimen), dorsal rays 15–33, anal rays 9–25, caudal rays 2 + 2. Description made from a 55.9mm specimen from IFO Station MWT 1 (measurements in mm): head 2.9, snout 1.1, eye 0.7, cleft of mouth 1.6, post-orbital 1.2, snout-vent 26.4, preanal 51.7, predorsal 51.1, depth just before eye 1.7, at branchial aperture 2.4, at vent 7.0, at midpoint of caudal region 6.5. Dorsal rays 33, anal rays 19, caudal rays 2 + 2. Teeth $\frac{1 + \text{IV} + 3}{1 + \text{V} + 3}$. Myomeres 52 + 60 = 112. First vertical blood vessel at myomere 17, last at myomere 52. Anterior margin of gall bladder at myomere 16.

Body elongate, much compressed except along head region, relatively shallow, its maximum depth at about the midpoint of the body and contained eight times in the total length, tapering only gradually in front of, and behind, midpoint. Head not conspicuously differentiated from trunk, short, about 19 times in total length, snout relatively short, contained about 2.6 times in head length, rounded, with the dorsal profile convex; nasal organ oval with a tubular anterior nostril and the posterior nostril as a simple aperture placed in front of the anterodorsal corner of the eye; eye oval in this specimen, its horizontal diameter about four times in head length; cleft of mouth oblique, reaching to below posterior margin of pupil; teeth generally small, relatively acute, in each jaw in three groups on each side, arranged as follows: an anterior grasping tooth on extreme tip of snout followed by a second group of four much larger teeth and then by three distinctly smaller teeth; those of the lower jaw similar in size and distribution; the total number of teeth on each side of upper and lower jaws not exceeding nine in number. Branchiostegal rays not well enough developed to be counted. Pectoral fin absent in all specimens; dorsal fin very short, but nevertheless clearly observable, originating at a point equal to the length of the head in advance of caudal tip and a little in advance of level of anal origin; anal shorter, but similarly developed; caudal rounded, supported relatively indistinctly by two short hypurals each bearing two rays.

Pigmentation without exception in all specimens restricted to the chorioid of the eye.

REMARKS. The present species is the first of a group to be discussed below which are distinguished immediately from all preceding muraenid species in having the dorsal and anal fins reduced to vestiges at the tip of the caudal region. In all of the following eight species the fin-rays are few in number but are nevertheless well developed and can easily be counted. This reduction in the dorsal and anal fins restricts the identification of these leptocephali to either *Uropterygius* Rüppell, 1835 or *Anarchias* Jordan & Starks, 1906. The major character by which these two genera are distinguished in the metamorphosed eel is the presence in *Anarchias* of a conspicuous cephalic sensory pore immediately behind, and in contact with, the posterior nostril. This pore has been regarded by some authors to be a part of the posterior nostril. Cephalic sensory pores in general do not appear in leptocephali until late in larval development, and this could be expected to be a barrier to the separation of larvae of the two genera. Fortunately, there is a single 79.0mm metamorphic specimen (listed below under *L. Anarchias* sp. 125–128 myomeres) which unmistakably shows this feature, and from this specimen the characteristic morphology of leptocephali of *Anarchias* has been determined.

The species described above is unusual amongst muraenid leptocephali in having no pigment (except that in the chorioid), and this appears to be a feature of *Anarchias* leptocephali, together with the vestigial dorsal and anal fins. It has



TEXT-FIG. 3.—Figs. A–C, *L. Anarchias* sp. (96–111 myomeres), 55.9mm total length, IFO Station MWT1: Fig. A—lateral view; Fig. B—lateral view of head; Fig. C—tip of caudal region. Figs. D-F—*L. Uropterygius* sp. (102–107 myomeres), 36.4mm total length, IFO Station S.10. Figs. G–H—*L. Uropterygius* sp. (115–122 myomeres), 44.2mm total length, IFO Station S.6.

a relatively low number of myomeres (96–111) and this range is larger than in any other muraenid species described here. However, with the exception of one specimen with 96 myomeres the number in all specimens lies within the narrower range of 103–111, but I am hesitant, without further material, of separating this single specimen from the remainder on this basis.

As far as can be determined from the literature there are only two named species of *Leptocephalus* which possibly conform in general pigmentation and reduction of fins with the above pattern. These are *L. euryurus* Lea, 1913 (with 116–117 myomeres), and *L. similis* Lea, 1913 (with 110 myomeres), both Atlantic species. The former has " only a series of small dots along the outer margin of the embryonic anal fin " while the latter has " only a few spots in the brain portion "—see Lea, 1913, pp. 26–27. As it is difficult to determine from Lea's account and figures (pl. 4, nos. 4–6) the exact extent of the reduction of the dorsal and anal fins, *L. euryurus* and *L. similis* cannot finally be identified with *Anarchias*.

Deraniyagala (1934, p. 96, figs. 10–11) briefly describes and illustrates two leptocephali which are clearly referable to *Anarchias*. They have the same reduced dorsal and anal fins, pectoral absent and no conspicuous pigmentation. The second of these, Larva IX, has 55 + 46 = 101 myomeres and 28 rays in the " caudal ", and is here referred to the present species described above. The first, Larva VIII, has 69 + 52 = 122 myomeres and 45 " caudal " rays, and is referred to the second species described here in *Anarchias*.

L. Anarchias sp. (116-122 myomeres).

1934. Larva VIII Deraniyagala, *Ceylon J. Sci.*, 19 B(1): 96, fig. 10.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (13 specimens)*: 41.0mm total length, IFO Station A57–3–3, 22° 37′ S, 166° 20′ E, 6/3/57 (1930hrs), S1/2mH, ca. 200m; 55.9, St 57–6–9, 22° 31′ S, 166° 21′ E, 12/10/57, Hel (Heligoland larval fish net), 0, ca. 133m; 54.2, St P58–3–3, 22° 45′ S, 166° 30′ E, 7/3/58 (1930hrs), S1/2mH, ca. 15m; 27.9, St S 1m C, 10 miles west of Bulari Pass, New Caledonia, 29/11/61, S1mH, ca. 90m; 23.6, 68.0, St S 1m 1, 10 miles west of Bulari Pass, New Caledonia, 30/11/61, S1mH, ca. 67m; 67.7, St S 1m 6, 10 miles west of Bulari Pass, New Caledonia, 30/11/61, S1mH, ca. 120m; 47.9, St G 26, 23° 17′ S, 165° 44′ E, 4/4/62, MWT3, H, ca. 17m; 59.5, St S.4, 15° 48′ S, 161° 00′ E, 9/6/62, MWT5, H, ca. 95m; 58.4, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 43.2, St S. 7, 10° 48′ S, 159° 00′ E, 12/6/62, MWT5, H, ca. 95m; 44.3, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m; 63.5, St 7–4, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 35m.

Western Australian Museum Collection (1 specimen): 46.1, Acc. No. P5168, *Lancelin*, 30 miles west of West End, Rottnest Island, Western Australia, 26/7/61 (0250–0350hrs), larval net, 110m.

DESCRIPTION AND REMARKS. 14 specimens: total lengths 23.6mm–68.0mm, myomeres 116–122 (55–64 + 52–63), first vertical blood vessel at myomere 16–19, last at myomere 56–63, anterior margin of gall bladder at myomere 15–18, teeth $\frac{1 + \text{II-III} + 2\text{-}5}{1 + \text{III-V} + 2\text{-}3}$ (absent in two metamorphic specimens), dorsal rays 21–40, anal rays 14–23, caudal rays 2 + 2.

Except in number of myomeres there appear to be no essential differences between this species and the preceding. Unlike members of *Gymnothorax* already described, there is no pattern of increasing size of larvae from a suggested northerly spawning area in this species, the only one of *Anarchias* for which there are sufficient specimens available to comment on the location of spawning areas.

L. Anarchias sp. (125–128 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (3 specimens)*: 20.4mm total length, 21.5, IFO Station S 1m 3, 10 miles west of Bulari Pass, New Caledonia, 30/11/61, S1mH, ca. 67m; 79.0, St 7–2, 22° 35′ S, 166° 16′ E, 17/7/62, MWT5, H, ca. 70m.

DESCRIPTION AND REMARKS. Three specimens: total lengths 20.4mm–79.0mm, myomeres 125–128 (59–60 + 65–69), first major vertical blood vessel at myomere 16–17, last at myomere 56–61, anterior margin of gall bladder at myomere 20, teeth $\frac{1 + \text{II-III} + 2}{1 + \text{IV} + 1}$ (absent in the largest metamorphic specimen), dorsal rays (1 specimen) 49, anal rays 29, caudal rays 2 + 2.

The large metamorphic specimen possesses the conspicuous cephalic sensory pore behind the posterior nostril, the character from which the identification of these *Anarchias* leptocephali has been made. It also has the highest number of dorsal and anal fin-rays within the three species described here, a number which, in view of the development of the specimen, is probably close to the final number in the adult.

L. Uropterygius sp (102–107 myomeres), Text-fig. 3, D-F.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (3 specimens)*: 29.5mm total length, IFO Station S.7, 10° 48′ S, 159° 00′ E, 12/6/62, MWT5, H, ca. 95m; 31.5, St S.8, 9° 35′ S, 161° 00′ E, 18/6/62, MWT5, H, ca. 95m; 36.4, St S.10, 17° 40′ S, 162° 25′ E, 22/6/62, MWT5, H, ca. 95m.

C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (1 specimen): 44.3, *Fairwind*, Kieta (Bougainville Island, Solomon Islands), 21/10/49, submarine light.

DESCRIPTION. Four specimens: total lengths 29.5mm–44.3mm, myomeres 102–107 (56–69 + 38–49), first vertical blood vessel at myomere 16–18, last at myomere 50–59, anterior margin of gall bladder at myomere 16, teeth $\frac{1 + \text{IV-V} + 3}{1 + \text{V-VI} + 2\text{-}3}$ (absent in the largest metamorphic specimen), dorsal rays 13–28, anal rays 9–22, caudal rays 2 + 2. Description made from a 36.4mm specimen, IFO Station S.10 (measurements in mm): standard 35.7, head 2.4, snout 0.9, eye 0.6, cleft of mouth 1.2, postorbital 1.0, snout-vent 21.0, predorsal 34.6, preanal 35.0, depth just before eye 1.2, at branchial aperture 1.9, at vent 5.3, at midpoint of caudal region 4.6. Dorsal rays 16, anal rays 11, caudal rays 2 + 2. Teeth $\frac{1 + \text{V} + 3}{1 + \text{VI} + 2}$. Myomeres 56 + 49 = 105. First vertical blood vessel at myomere 18, last at myomere 52. Anterior margin of gall bladder at myomere 16.

Body elongate, much compressed except along head region, moderately shallow, its greatest depth at vent (or slightly behind the midpoint of body) and contained about seven times in total length, tapering more gradually in front of this point. Head not conspicuously differentiated from trunk, short, about 15 times in total; snout relatively short, about 2.6 in head, blunt and rounded, with the dorsal profile convex; nasal organ oval with a tubular anterior nostril and a simple posterior nostril placed close to anterodorsal corner of eye; teeth small and relatively acute, in both jaws on each side not exceeding 10 in number and in three groups: an anterior grasping tooth, a second group of larger teeth, and a third group of small teeth. Branchiostegal rays not well enough developed to be counted. Pectoral fin absent in all specimens. Dorsal fin very short, originating subterminally and slightly in advance of level of anal origin; anal fin also very short and originating subterminally; caudal rounded and together with dorsal and anal fins, giving a fanlike appearance to caudal tip.

Pigmentation generally inconspicuous, the chromatophores always small and rather compact, but some (those on the dorsal midline) consisting of a minute, central point surrounded by a diffuse ring of brownish pigment. In detail the pigmentation is as follows: five deep chromatophores on the ventral aspect of the myelencephalon; seven chromatophores in an almost vertical line on the branchial region; a single, midventral line of elongate, flattened chromatophores below the intestine from the throat to the vent, these chromatophores spaced at about one per segment anteriorly, but at about four per segment for most of the length of the intestine; this series continues along the ventral body wall to the anal origin; a single, mid-dorsal line of diffuse chromatophores from about segment 10 to about 20 segments short of the dorsal origin, the chromatophores spaced at about one per segment; a pair of chromatophores ventrally on the spinal cord for each spinal ganglion for the whole length of the nerve cord.

REMARKS. The final five species to be discussed in this paper all belong with the *Uropterygius-Anarchias* group in having much reduced dorsal and anal fins. Furthermore, there is no trace, even in metamorphic specimens, of a cephalic sensory pore behind the posterior nostril. Leptocephali of *Anarchias* have already been characterised so that in consideration of this and the above characters an identification of the present five species with *Uropterygius* can confidently be made. These species are all characterised by having in addition to the two features listed, pigmentation on the head region, in a single, ventral, somatic row along the intestine, continuing to the base of the anal, a mid-dorsal line in advance of the dorsal origin and along the spinal cord.

Within this group of five species of *Uropterygius,* there are two subdivisions, distinguished from one another by an obvious but rather minor difference in pigmentation, similar to the difference shown between the two groups of *Gymnothorax* leptocephali. As in *Gymnothorax*, this difference is regarded to indicate a possible subgeneric division of *Uropterygius.* In the first group of three species, of which the species described above is typical, there is an almost vertical line of chromatophores on the branchial region, a few pigment spots on the hind part of the brain, a line of mid-dorsal chromatophores beginning at segment 10 and continuing to about 20 segments in advance of the dorsal origin, pigment spots along the whole of the spinal cord and a ventral, somatic row from the throat to the anal origin (the spots between the vent and the anal origin closer together than those in front). In the second group of two species the distribution of pigment is essentially similar except that there is a wide scattering of chromatophores over the dorsal surface of the head, there is a chromatophore at the base of almost every dorsal and anal ray, and the ventral row does not begin until 30 or more segments from the head.

Gosline (1958, pp. 221–223) lists 13 species of *Uropterygius* from the Central Pacific of which none have been examined in detail for vertebral counts. Ancona (1928, p. 10) gives a count of 117 vertebrae for (?)*U. concolor* Rüppell, 1835 (from Grassi, 1913) and although this species may possibly be confused with *U. sealei* Whitley, 1932, and *U. inornatus* Gosline, 1958, the two other plain brown Pacific species, it is probable that Grassi correctly identified the specimen from which this count was made. I have examined a specimen of *U. marmoratus* (Lacépède, 1803) (as identified from Gosline's key) from Suva, Fiji, and find that the vertebrae number 121. With the vertebral counts of only two of the dozen or so species of *Uropterygius* known it would therefore be unwise, at the present time, to assign specific identifications to this group of leptocephali.

L. Uropterygius sp. (116-123 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 44.5mm total length, IFO Station S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m.

C.S.I.R.O. Division of Fisheries and Oceanography (Cronulla) Collection (2 specimens): 34.1, *Warreen* Station 7/40, 30° 13′ S, 153° 33′ E, 14/1/40, N100, O, 0m–200m; 56.2, *Fairwind*, Dugumur Bay, New Guinea, 22/12/48, submarine light.

DESCRIPTION AND REMARKS. Three specimens: total lengths 34.1mm–56.2mm, myomeres 116–123 (59–74 + 45–58), first vertical blood vessel at myomere 17–19, last at myomere 59–61, anterior margin of gall bladder at myomere 19–21, teeth $\frac{1 + IV + 2\text{-}3}{1 + IV + 2}$ (absent in the largest specimen), dorsal rays 14–26, anal rays 9–16, caudal rays 2 + 2.

The present species is readily distinguished from the preceding in having an appreciably higher number of myomeres.

L. Uropterygius sp. (150 myomeres).

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (1 specimen)*: 26.0mm total length, IFO Station S.2, 20° 10′ S, 163° 27′ E, 7/6/62, MWT5, H, ca. 95m.

DESCRIPTION AND REMARKS. One specimen: myomeres 83 + 67 = 150, first vertical blood vessel at myomere 17, last at myomere 75, anterior margin of gall bladder at myomere 21, teeth $\frac{1 + II + 3}{1 + II + 4}$, fin-rays undeveloped.

This species has a relatively high number of myomeres for *Uropterygius* larvae, with the last vertical blood vessel placed conspicuously further back than in the two species already described.

L. Uropterygius sp. (115-122 myomeres), Text-fig. 3, G-H.

MATERIAL EXAMINED. *Centre d'Océanographie de l'Institut Français d'Océanie Collection (8 specimens)*: 40.9mm total length, IFO Station 56–4–3b, 14° 01′ S, 170° 05′ E, 27/9/56 (1113hrs), S1/2mH, ca. 10m; 36.2, St LL 61–1–1, 20° 30′ S, 163° 23′ E, 8/3/61, stomach of lancet fish, *Alepisaurus ferox*; 40.3, St S.5, 13° 30′ S, 162° 05′ E, 10/6/62, MWT5, H, ca. 95m; 29.7, 35.0, 38.6, 40.0, 44.2, St S.6, 11° 51′ S, 159° 13′ E, 11/6/62, MWT5, H, ca. 95m.

DESCRIPTION. Eight specimens: total lengths 29.7mm-44.2mm, myomeres 115–122 (64–74 + 43–58), first major vertical blood vessel at myomere 13–15, last at myomere 57–62, anterior margin of gall bladder at myomere 20–21, teeth $\frac{1 + IV + 2\text{-}4}{1 + IV\text{-}V + 2\text{-}3}$, dorsal rays 6–43, anal rays 8–26, caudal rays 2 + 2. Description made from a 44.2mm specimen from IFO Station S.6 (measurements in mm): head 2.7, snout 1.0, eye 0.6, cleft of mouth 1.5, postorbital 1.2, snout-vent 26.2, predorsal 42.4, preanal 42.1, depth just before eye 1.5, at branchial aperture 2.6, at vent 6.0, at midpoint of caudal region 6.6. Dorsal rays 43, anal rays 21, caudal rays 2 + 2. Teeth $\frac{1 + IV + 4}{1 + V + 3}$. Myomeres 64 + 58 = 122. First vertical blood vessel at myomere 14, last at myomere 59. Anterior margin of gall bladder at myomere 20.

Body elongate, much compressed except along head region, deep, its greatest depth well behind the midpoint and about 6.5 in total length. Head not conspicuously differentiated from trunk, short, contained about 16 times in total; snout short, 2.7 in head, rounded; nasal organ oval, anterior nostril subtubular and posterior nostril a simple aperture placed close in front of anterodorsal corner of eye; eye oval, its horizontal diameter 4.5 in head; cleft of mouth oblique, reaching to below posterior margin of pupil; teeth in three groups on each side of the jaws. Pectoral fin absent; dorsal fin originating only slightly in advance of caudal tip; anal similar, its origin slightly behind level of dorsal origin; caudal rounded.

Pigmentation in formalin inconspicuous but nevertheless invariably in several clearly-defined areas as follows: a patch of about 12 small chromatophores on the dorsal surface of the head above the cerebellum; seven pigment spots on the ventrolateral aspect of the myelencephalon; five chromatophores on the most anterior part of the spinal cord; 10 in an almost vertical line at the level of the branchial aperture; a single, longitudinal, somatic series below the intestine from segment 30 to the vent, spaced at about one chromatophore for every two or three segments; this line is continuous with a line of more closely-set, minute pigment spots on the ventral body wall from the vent to the anal origin; a chromatophore on the base of nearly every dorsal and anal ray; a line of deep chromatophores on the ventral aspect of the spinal cord beginning at myomere 15, spaced at about one per segment posteriorly, but more widely spaced anteriorly.

REMARKS. The species described here differs from the preceding three species in having pigment spots on the dorsal aspect of the head, on the bases of the dorsal and anal fins and in having the ventral row beginning much further back along the body (differences which are discussed above).

L. Uropterygius sp. (118 myomeres).

MATERIAL EXAMINED. *Western Australian Museum Collection (1 specimen)*: 48.0mm total length, Acc. No. P5237, *Lancelin*, 19 miles west of West End, Rottnest Island, Western Australia, 4/4/62 (0230hrs), larval net, 37m.

DESCRIPTION AND REMARKS. One specimen: myomeres 99 + 19 = 118, first major vertical blood vessel at myomere 20, last at myomere 69, anterior margin of gall bladder at myomere 19, teeth $\frac{1 + IV + 2}{1 + VI + 2}$, dorsal rays 44, anal rays 26, caudal rays 2 + 2.

Although the present species has a myomere number which would place it within the range shown for the preceding species (115–122) it is distinguished from the latter in having the vent placed almost subterminally so that preanal myomeres make up a large proportion of the total. It also has the ventral row of chromatophores very widely spaced. Both *U. sealei* and *U. tigrinus* (Lesson, 1828) have the vent placed almost two-thirds of the way along the body (that is to say these species have a short tail) and the present leptocephalus may possibly be referable to either one of these species.

GENERAL DISCUSSION

The present study material was assembled from collections made from a wide area in the Australasian region, including broadly the following: (1) the New Caledonia area as far north as the equator to about 23° S. and between 158° E and 177° E (collections made by the Centre d'Océanographie de l'Institut Français d'Océanie, Nouméa), (2) eastern Australia and the eastern half of New Guinea and the Solomon Islands (collections made by the C.S.I.RO. Division of Fisheries and Oceanography, Cronulla, N.S.W., and the Australian Museum, Sydney) and (3) off Rottnest Island, Western Australia (collections made by the Western Australian Museum, Perth). The largest proportion of the muraenids in the collection (94 specimens) were collected by the *Orsom III* (the oceanographic vessel attached to the IFO, Nouméa) from 1956–1962 at 41 biological stations using 0.5m plankton nets and 3ft or 5ft Isaacs-Kidd midwater trawls; a single specimen was taken from the stomach of a lancet fish (*Alepisaurus ferox* Lowe) longlined off New Caledonia. Those specimens in the collection of the DFO (Cronulla) were collected by the F.R.V. *Warreen,* using standard plankton

nets, off eastern Australia in a planktological survey of this coast during 1938–42, and by the F.S.V. *Fairwind* in New Guinea and the Solomons, using a submerged light and net, in a fisheries survey of this area during 1948–1950. A few specimens were taken as beachcast individuals on the New South Wales coast (in the collection of the Australian Museum). Finally, a few other specimens were collected by the vessel *Lancelin* off the western Australian coast (Western Australian Museum).

Muraenid leptocephali, as characterised here, make up an easily recognisable homogeneous group which show few similarities as a whole to other groups representing other families of eels. They are usually of moderate size and thus differ from congrid larvae which may at full growth be anything from 60mm to over 300mm total length depending upon the genus to which the congrid belongs. Anguillid and serrivomerid larvae are about the same size as muraenids when full grown. The body is never very deep as in some congrids, nettastomids and in *L. Cyema atrum*. The snout is usually short, blunt and rounded as in some congrids but is never beaklike as is found in most ophichthid and nemichthyid larvae. The rounded caudal fin is a most definitive, unique, and conspicuous feature. The vent is placed normally in the posterior third of the body in muraenid leptocephali, but this is a similar condition as occurs in some congrids and in the serrivomerids. The number of teeth on each side of the jaws rarely exceeds 10 even at full growth; muraenid larvae are thus readily distinguished from angullid and congrid larvae in which the number may reach 20. In having the pectoral fin much reduced or absent muraenid leptocephali are exactly similar to ophichthids and are easily distinguished from anguillids, congrids and serrivomerids, at least. Myomeres are moderate in number for eels in general, but these larvae cannot be confused with larvae of nemichthyids which have usually more than 200 myomeres. Pigmentation is variable amongst the various genera of muraenid larvae, but unlike most other families (with the exception of the Anguillidae) pigment is not known to occur on the lateral body surface. One genus in particular (*Gymnothorax*), in having ventral somatic chromatophores along the anterior portion of the gut region and splanchnic chromatophores above the gut along the posterior portion, shows remarkably close similarities to *Ariosoma* (Congridae).

Generic divisions, as suggested in this account, are readily recognisable, as set out in the above descriptions of the various species. In consideration of many factors, there are clearly seven which correspond well with the established generic divisions of the Muraenidae as based on adult morphology. Larvae of two of these genera (*Gymnothorax* and *Uropterygius*) show subgeneric divisions which have not been firmly established in the adults (although *Siderea* has on occasions been separated from *Gymnothorax*).

Inadequate knowledge of the 67–70 Indo-Pacific species of muraenid eels in respect of vertebral counts is clearly a barrier to definitive identifications of the 26 larvae here described. There is therefore an urgent need for a re-examination of Indo-Pacific muraenids for this character so that the present leptocephali, as well as any others which may be collected in the future, may be more firmly identified. Furthermore, to eliminate the tentative nature of generic identifications of leptocephali belonging to such forms as ?*Rabula* and ?*Echidna*, collections should be made in areas where metamorphosis is known to take place for metamorphic larvae which show both larval and juvenile characters. Reference to station data already presented shows that the most suitable conditions would possibly be close in to the reefs along tropical coasts using submerged lights and nets during the early to middle summer months.

The 113 specimens range in size from 20.4mm to 82.1mm in total length, although the majority of specimens are about 40mm–50mm, and the collection thus includes larvae in which the fin-rays have not yet developed, full-grown larvae and metamorphic specimens which have lost their larval teeth, the vent is placed relatively far forwards along the body, larval pigment is in the process of being lost and the body is taking on the shape of the elver. In only three or four of the 26 species described in this paper are there sufficient numbers of small larvae to suggest adequately the possible location of spawning areas. Although the collection includes full-grown larvae of most of these species, these may not necessarily have been collected some distance from the spawning area of the species concerned, as some individuals may remain and achieve full-growth in the immediate area of adult spawning. Nevertheless, examination of size ranges and locations of capture suggests in a very general way that for many of the 26 species spawning occurs in an area north of New Caledonia and eastwards of the Solomon Islands.

This observation is based upon the assumption that the sampling methods used in the collection of the muraenid leptocephali described here have not excluded small larvae where these were present. The moderate number of small larvae in the collection shows this to be true. Although a few hauls in which muraenid leptocephali were taken reached 300m, the majority were made in less than 100m but few surface tows were taken. Very young muraenid leptocephali may therefore occur either in rather deep or very shallow oceanic waters, although this is unlikely.

Plankton collections were made in the New Caledonia area by the Institut Français d'Océanie discontinuously from 1956 to 1962, but nevertheless all months of the year are covered by these collections. Although there are no clear trends shown in comparing the lengths of larvae collected at different times of the year, a general observation is that hauls made during June to August tend to contain a high proportion of half-grown to full-grown larvae (40mm–60mm). Hauls made earlier in the year (April–May) contain a greater number of smaller larvae (less than 40mm). Large metamorphic larvae of over 60mm were taken in moderate numbers during October-December, 1949, by the *Fairwind* in New Guinea waters and the Solomons. Metamorphic larvae are also known from the New South Wales coast, and these appeared as beachcast specimens in December to March. These observations would suggest a late summer spawning of adults, a relatively rapid growth to reach about 60mm–70mm during September-October and then metamorphosis to the elver during October-December. If this pattern of early development is correct, then muraenids normally have a very short larval life (eight to ten months) compared with that of *Anguilla anguilla* in the Atlantic (two to three years) and appreciably shorter than the congrid eel, *Ariosoma mauritianum* (Pappenheim, 1914), which is at least one year, as already determined (Castle, 1964, p. 12).

LITERATURE CITED

ANCONA, U. d' 1928. Muraenoidi (Apodes) del Mar Rosso e del Golfo di Aden. Materiali raccolti dal Prof. L. Sanzo nella campagna della R.N. "Ammiraglio Magnaghii" 1923–24. *Mem. R. Com. talassogr. ital.*, 146: 1–146, 5 pls.

CASTLE, P. H. J., 1963a. Anguillid leptocephali in the south-west Pacific. *Zool. Publ. Vict. Univ. N.Z.*, 33: 1–14, 3 figs.

———— 1963b. The systematics, development and distribution of two eels of the genus *Gnathophis* (Congridae) in New Zealand waters. *Zool. Publ. Vict. Univ. N.Z.*, 34: 15–47, 10 figs.

CASTLE, P. H. J., 1964. Congrid leptocephali in Australasian waters with descriptions of *Conger wilsoni* (Bl. & Schn.) and *C. verreauxi* Kaup. *Zool. Publ. Vict. Univ. N.Z.*, 37: 1–45, 11 figs.

——— 1965. Leptocephali of the Nemichthyidae, Serrivomeridae, Synaphobranchidae and Nettastomidae in Australasian waters. *Trans. roy. Soc. N.Z., Zool.*, 5(4): 131–146, 2 figs.

EIGENMANN, C. H., and KENNEDY, C. H., 1902. The leptocephalus of the American eel and other American leptocephali. *Bull. U.S. Fish Comm.*, 21: 81–92, figs.

GOPINATH, K., 1950. On a few leptocephali from the Trivandrum coast. *Rec. Indian Mus.*, 47(1): 87–98, 1 fig., 1 pl.

GOSLINE, W. A., 1958. Central Pacific eels of the genus *Uropterygius*, with descriptions of two new species. *Pacif. Sci.*, 12(3): 221–228, 2 figs., 2 tabs.

GRASSI, B., 1910. Contribuzione allo studio dello sviluppo dei Muraenoidi. *Soc. Ital. Progr. Sci.*, Mem. 1.

JONES, S., and PANTALU, V. R., 1952. On the metamorphosing stages of the talabon eel, *Muraenesox talabon* (Cantor) with descriptions of some leptocephali from the estuaries of Bengal and Orissa. *J. Asiat. Soc. Beng.*, 18(2): 129–140.

LEA, E., 1913. Muraenoid larvae from the "Michael Sars" North Atlantic Deep-Sea Expedition, 1910. *Rep. Sars N. Atl. Deep Sea Exped.*, 3(2): 1–48, 38 figs., 6 pls.

NAIR, R. V., 1947 On the metamorphosis of two leptocephali from the Madras plankton. *Proc. Indian Acad. Sci.*, 25B(1): 1–14.

——— and MOHAMED, K. H., 1960. Studies on the leptocephali of Bombay waters. V. A few other leptocephali. *Proc. Indian Acad. Sci.*, 52B: 209–219, 2 figs., 1 tab., 1 pl.

PANTALU, V. R., and JONES, S., 1954. On some metamorphosing stages of eels (Muraenidae) from the estuary of the Burhabulong River, Orissa State. *Proc. Indian Acad. Sci.*, 39(1): 24–35, 4 figs.

P. H. J. CASTLE, M.Sc., Ph.D.,
Department of Zoology,
Victoria University of Wellington,
P.O. Box 196, Wellington, N.Z.